# SEMICONDUCTOR DEVICE AND METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE

## CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims benefit of priority under 35USC §119 to Japanese patent application No. 2002-74633, filed on Mar. 18, 2002, the contents of which are incorporated by reference herein.

## BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a semiconductor device and a method of manufacturing a semiconductor device, and in particular, to a structure of a junction terminating region portion of a power semiconductor device which is suitable for a switching element for electric power.

[0004] 2. Related Background Art

[0005] In response to the demand to make electrical power equipment compact and high-performance in recent years in the power electronics field, performance improvements with respect to making lowering loss, increasing speed and improving the ruggedness have been carried out in addition to making them have a high breakdown voltage and making them able to handle great current in the power semiconductor devices. Among them, a power MOSFET (Metal Oxide Semiconductor Field Effect Transistor) has been established as a key device in the switching power source field or the like because of the high-speed switching performance thereof.

[0006] Because the MOSFET is a majority carrier device, the MOSFET has an advantage that there is no minority carrier storage time and switching is fast. However, on the other hand, because there is no electric conductivity modulation, a device which has a high breakdown voltage is disadvantageous with respect to the ON-state resistance as compared with a bipolar device such as an IGBT (Insulated Gate Bipolar Transistor) or the like. This results from the fact that the higher the breakdown voltage a device has, the more the ON-state resistance of the MOSTFET increases, because it is necessary to make an n type base layer thicker and to make the impurity concentration lower in order to obtain a higher breakdown voltage in the MOSFET.

[0007] The ON-state resistance of the power MOSFET greatly depends on the electrical resistance in a conductive layer (n type drift layer) portion. Further, the impurity concentration determining the electrical resistance at the n type drift layer cannot rise to greater than or equal to the limit, in accordance with the breakdown voltage of the pn junction which the p type base and the n type drift layer form. Therefore, a trade-off relationship exists between the device breakdown voltage and the ON-state resistance. It is important to improve this trade-off for a low electric power consumption device. In this trade-off, there is a limit which is determined by the material of the device, and this limit must be exceeded in order to realize a low ON-state resistance device exceeding existing power devices.

[0008] As one example of MOSFETs for solving this problem, a structure is known in which a resurf structure called a super junction structure is buried in an n type drift layer. A conventional power MOSFET having a super junction structure will be described with reference to **FIG. 36**. Note that, in the following figures, like parts are denoted by like reference numerals, and detailed descriptions thereof will be omitted.

[0009] **FIG. 36** is a cross-sectional view showing a schematic structure of one example of a conventional power MOSFET. In the MOSFET shown in the view, an n+ type drain layer **100** is formed on one surface of an n− type drift layer **102**, and a drain electrode **40** is formed on the n+ type drain layer **100**. Further, a plurality of p type base layers **108** are selectively formed in the other surface portion of the n− type drift layer **102**, and n+ type source layers **110** are selectively formed in the surfaces of the respective p type base layers **108**. Further, a gate electrode **114** is formed on the surface region of the n− type drift layer **102** which are sandwiched by the adjacent p type base layers **108**, the surfaces of the p type base layers **108** sandwiching the n− type drift layer **102**, and the surface region of the portions of the n+ type source layer **110** facing each other via the p type base layers **108** and the n− type drift layer **102**, with a gate insulating film **112** interposed therebetween. Further, source electrodes **116** are respectively formed on the region of the surfaces of the n+ type source layer **110** and the surface of the p type base layer **108** so as to sandwich the gate electrode **114**. Moreover, in the n− type drift layer **102** between the p type base layer **108** and the n+ type drain layer **100**, a p type drift layer **106**, which is formed so as to form a resurf layer and is connected to the p type base layer **108**, is formed. In this way, the power MOSFET shown in **FIG. 36** has a vertical type resurf structure in which the p type drift layers **106** and the portions of the n− type drift layers **102** sandwiched by these p type drift layers **106** are alternately repeated in the lateral direction.

[0010] In an OFF-state, a depletion layer spreads at junctions between these p type drift layers **106** and n− type drift layers **102**. Even if the impurity concentration of the n− type drift layers **102** is made high, the n− type drift layers **102** and the p type drift layers **106** are completely depleted before breaking down. In accordance therewith, a breakdown voltage which is the same as that of the conventional MOSFET can be obtained.

[0011] The impurity concentration of the n− type drift layer **102** does not depend on a breakdown voltage of the device, but it depends on the width of the p type drift layer **106** and the width of the n− type drift layer **102** itself between these p type drift layers **106**. If the width of the n− type drift layer **102** and the width of the p type drift layer **106** are made narrower, the impurity concentration of the n− type drift layer **102** can be made much higher, and a greater reduction of the ON-state resistance and a higher breakdown voltage can be achieved.

[0012] At the time of designing such a MOSFET, the impurity concentrations of the n− type drift layer **102** and the p type drift layer **106** are important to determine the breakdown voltage and the ON-state resistance. In principle, due to the respective impurity concentrations of the n− type drift layer **102** and the p type resurf layer **106** being made equal, the impurity concentrations equivalently become zero, the high breakdown voltage can be obtained.

[0013] However, with respect to the semiconductor device having a conventional super junction structure, no structure